

EXHIBIT “L”

Deposition Exhibit 33

The Advanced Taser: a Medical Review

The Advanced Taser: a Medical Review

Anthony Bleetman PhD, FRCSEd, FFAEM, DipIMC RCSEd

Consultant in Accident and Emergency Medicine
Birmingham Heartlands Hospital, UK
Honorary Senior Clinical Lecturer, Dept of Surgery
University of Birmingham, UK

Richard Steyn FRCSEd (CTh) MRCP DipIMC RCSEd DRCOG

Consultant in Thoracic Surgery
Birmingham Heartlands Hospital, UK

April 27, 2003

EXHIBIT

33

Substance of instruction

I am Anthony Bleetman, a Consultant in Accident and Emergency Medicine employed by Birmingham Heartlands and Solihull NHS Trust. I am an Honorary Senior Clinical Lecturer in the Department of Surgery at the University of Birmingham. I hold the qualifications PhD FRCSEd FFAEM DipIMC RCSEd.

I have been instructed by Taser International to prepare this literature review describing the injury potential of the Advanced Taser product. I have been asked to draw conclusions on the device's relative safety and to identify potential medical issues in deploying this product.

I am engaged as an external consultant to Taser International for this project only. I have no other commercial interest in this product.

In the preparation of this report, I have been supported by Mr Richard Steyn, a Consultant Thoracic Surgeon, also employed by Birmingham Heartlands and Solihull NHS Trust. Mr Steyn holds the qualifications FRCSEd (CTh) MRCP DipIMC RCSEd DRCOG. He has expertise in chest and cardiac injuries and experience in pacemakers and implantable defibrillators. He assisted in the initial literature search and final review of this document.

Introduction

Modern policing requires police officers to safely control those posing a threat to themselves or to the public. Inevitably, techniques and devices have evolved to facilitate restraint and control, and these have become an integral part of policing. Reasonable techniques and devices must be effective in controlling violent suspects, while minimising the risk of injury to the suspect, arresting officers or bystanders, even when weapons have been produced by the suspect.

In recent years, the police have deployed batons, dogs, firearms, incapacitant sprays and electronic weapons. Each of these carries its own inherent risks and safety profile. Responsible risk management dictates that there is constant pressure to review techniques and devices and continually improve the safety profile while maintaining acceptable and reasonable risk.

The rationale of the Advanced Taser is to *'...be sufficiently effective to cause a physical debilitation in the target sufficient to render the target incapable of complex motor skills required for aggressive behaviour, and must be sufficiently safe that the risk of injury or death should be less than that for current less lethal technologies such as impact munitions...'*

This paper reviews the available relevant literature on electrical injury and describes the likely injury potential of the Advanced Taser, drawing conclusions on the device's relative safety and identifies potential medical issues in deploying this product.

Literature Review

An extensive computerised medical literature search on 'Medline' identified 75 publications reporting on the usage of electronic restraint devices or the medical hazards of electricity. These publications include information on the occurrence and purported mechanism of injuries and deaths. Published information on injuries and deaths associated with electronic weaponry is limited with 35 relevant articles being identified in peer-reviewed medical publications.

Taser International submitted four further published articles on the electrical properties of the skin [1,2,3,4].

All published medical literature on the effects of Tasers are based on experience with the original Taser or stun gun devices, and not on the more recent Advanced Taser. The Advanced Taser is a new weapon that has only recently been deployed. We have not identified any material published in peer reviewed medical literature on the medical effects of this new weapon.

Delivery of electricity

The Advanced Taser 26-Watt device was developed following attempts to improve the effectiveness of an earlier 7-Watt Taser system that was defeated by 'focused' volunteers who were able to fight through its effects. Trials of increasing the pulse rate and pulse power demonstrated that increases in pulse power were more effective than increases in the pulse rate. Animal experiments demonstrated that muscle was fully contracted at 1.76 Joules per pulse and that no relaxation occurred when the pulse rate exceeded 8 –10 pulses per second. The M26 Advanced Taser delivers a sequence of approximately half sine wave current pulses, each having a peak amplitude of about 18 Amps and a duration of about 11 microseconds [5]. The peak voltage output of the device is considered to be as high as 50,000 Volts. The peak power of each pulse is estimated to be 324,000 Watts. The average power being 26.4 Watts, each pulse having an energy of 1.76 Joules.

The stun gun delivers 40,000 to 100,000 V at only 3 to 4 mA and is said to produce impulses that are conducted more effectively along nerves than muscles (including cardiac muscle). This causes pain, uncontrollable muscle contraction, and loss of balance. The stun gun has been implicated in causing skin burns with negligible adverse neurological and cardiac injury [6].

Early tests on stun guns performed in 1989 produced variable results. This variability was attributed to poor quality control of the devices. The devices generated spikes greater than 100 kV with a repetition rate of 5 – 20 Hz. When applied to skin, the device generated a maximum current spike of 3.8 A for 20 microseconds. When the device was required to arc 3 mm to the skin, the maximum current spike generated was 190 A for 20 nseconds. The charge transferred ranged from 0.568 to 27.5 $\mu\text{C}/\text{cm}^2$, which was considered close to the calculated ventricular fibrillation threshold of 34 $\mu\text{C}/\text{cm}^2$ [7]. When tested on pigs, the devices were reported as being capable of inducing cardiac capture (generating additional heartbeats) at a rate of 5 cycles/sec. When applied through clothing, the stun gun was capable of inducing asystole (cardiac standstill) for as long as the device was applied. The device was also capable of inducing ventricular fibrillation in pigs fitted with pacemakers. The author suggests that the results of these animal tests imply that these devices may have the potential for lethality when used on a healthy individual. It was postulated that cardiac patients and individuals with implanted pacemakers maybe at highest risk [7]. These tests were subsequently replicated by Dr Stratbucker who advises that he was unable to duplicate these findings [8]. He postulates that the original research was flawed by inaccuracies and equipment error.

The US Consumer Product Safety Commission evaluated the early Taser in 1976. The Commission concluded that the Taser should not be lethal to a normal, healthy person [7].

Current frequency has an important effect of the injury potential of electricity. Alternating current at frequencies of the order of those used for power distribution has a more pronounced effect on sensation, nerve and muscle function than direct current and current at higher frequencies [9]. Direct current, and current at frequencies of more than 1000 Hz produce heat, while those at lower frequencies tend to generate pain and muscle contraction. Odell writes *'short pulses of high voltage (of the order of a few thousand volts for a few milliseconds, which carry little energy, produce a painful shock with a lesser tendency to*

disrupt muscular or cardiac function. This effect is exploited in devices such as electric fences and stun guns. The time interval between pulses is long enough so that the 'hold on' phenomenon is avoided and it is possible to let go the fence and move away'

Electricity can cause injury in three ways: the direct effect of electric current on the tissues, conversion of electrical energy to thermal energy, and blunt injury from muscle contractions or falls [10]. The extent of injury following electric shock is determined by voltage, resistance, amperage, type of current, current pathway, and the duration of contact [10]. The resistance to the flow of domestic electricity (low voltage, low frequency) into the body depends on the area of contact, the pressure applied, the magnitude and duration of current flow, and the presence of moisture. Skin is the primary resistor to the flow of this current into the human body [11]. Skin resistance varies very widely indeed as a function of thickness, vascularity, hydration, callosity and the area of the body to which the electricity is delivered.

High-voltage DC current tends to cause a single muscle spasm, often throwing the victim from the source causing blunt trauma [12]. Contact with a DC source can result in disturbances in cardiac rhythm, depending on the phase of the cardiac cycle.

The Advanced Air Taser delivers very high frequency electricity. This is dissimilar to both high-voltage DC current and also AC domestic or industrial supply. A 'skin effect' is known to exist when high frequency electricity is delivered. High frequency electrical currents tend to stay near the surface of a conductor; hence, the output of the Advanced Taser is believed to stay near the surface of the body in the skin and muscle tissue and does not penetrate into the internal organs. In this way, the electrical delivery of the Taser, and thus its injury potential, are likely to be different from other modes of electrical delivery and injury that have been described in numerous medical papers. The injury profile and mode of action on the human body will be different to those of domestic or industrial electricity sources of both alternating and direct current [8].

Clinical experience with electronic weaponry

Kornblum and Reddy describe a series of 16 deaths in police suspects who had been subjected to the Taser [13]. These deaths occurred between 1983 and 1987. All subjects were male, aged between 20 and 40 years of age. All were known to use illicit drugs. Each was engaged in some bizarre form of behaviour on the arrival of Police Officers. Several had been subjected to other trauma during arrest. These included empty hand skills, batons and firearms. In 13 of the 16, the presence of drugs was confirmed at autopsy.

One subject had pre-existing heart disease that had previously resulted in hospital admission and a recommendation for a permanent pacemaker. This subject had previously declined medical intervention for his cardiac problem. At autopsy, this subject also had significant blood levels of illicit drugs.

The authors state that although in two of these deaths the Taser electrical delivery was cited as a cause, this was not proven. In one of these subjects, very high blood levels of cocaine were found; the other was the former cardiac patient who had suffered blackouts previously. At autopsy, significant heart disease was evident.

The authors suggest that these deaths were very similar to the majority of deaths in custody. The common threads being the presence of drugs and exhibition of bizarre behaviour at the time of arrest. The authors go to describe that there had been no reported skin injuries or complications from the Taser barbs. Most barbs had been fired at the chest, abdomen, back or thighs. No barb injuries to the eyes or other sensitive areas had been described. The authors expressed concern about the potential for eye injury and blindness. The potential for injury after falling in 'tasered' subjects was described.

The authors' conclusions were challenged by Allen, a forensic pathologist who expressed concern that certain medical conditions, including drug use and heart disease, may increase the risk that the Taser will be lethal [14]. The methods of collating and reporting the data on the 16 deaths were challenged. Allen argues that the Taser was at least contributory in 9 of these 16 deaths. He argues that it seems only logical that a device capable of depolarising skeletal muscle can also depolarise heart muscle and cause fibrillation under certain circumstances. He continues: *'while the use of Tasers may be generally safe in healthy adults,*

pre-existing heart disease, psychosis, and the use of drugs including cocaine, PCP, amphetamines and alcohol may substantially increase the risk of fatality. Since Tasers are likely to be used on psychotic or intoxicated individuals, in whom the medical history is unknown, the priorities for use among law enforcement's "non-lethal" armamentarium must be carefully considered'.

Ordog [15] describes a prospective case study of 218 patients who had been brought to the emergency department of a Los Angeles hospital after being shot with a Taser, between July 1980 and December 1985. Most of these patients had exhibited bizarre behaviour at the time of their arrest. Most had either taken drugs or alcohol on the day of their arrest. 15% had pre-existing diseases. Three of these patients arrived at hospital in cardiac arrest. None of these responded to resuscitation attempts and died. Two of these patients had no previous medical history and went into cardiac arrest 5 and 15 minutes after being shot with the Taser. The third had a pre-existing cardiac history and went into respiratory arrest followed by cardiac arrest 25 minutes after being shot with the Taser. All three had high levels of PCP in their blood. PCP toxicity was the cited cause of death in all three. 38% had associated injuries related to their violent behaviour and not to the use of the Taser. Mild rhabdomyolysis [muscle breakdown] had occurred in 1% of patients. It could not be determined if this developed secondary to PCP abuse or to the muscular contractions caused by the Taser. One patient developed a testicular torsion after being 'tasered', and another claimed that he became sterile. 'Tasered' patients spent an average of 6½ hours in the emergency department. Two thirds had a psychiatric evaluation and half of these were subsequently admitted to a psychiatric facility. 92% of patients had no recollection of being 'tasered'. None had any permanent morbidity following Taser use.

This 'tasered' population was compared to 22 patients shot by police using .38 Special handguns. 25% of victims had evidence of recent drug or alcohol use. Half of those subjects shot by firearms died.

The author draws a number of conclusions:

- Many subjects need medical treatment for minor trauma as they usually fall when 'tasered'.
- Most are seen in the emergency department for barb removal.

- The pre-existing injuries and toxic conditions leading to the patient being 'tasered' are the major problems requiring medical treatment. This was usually due to the toxic psychosis of PCP and to injuries sustained from the violent behaviour associated with it.
- Three patients died, probably due to cardiac arrhythmia in a pre-existing irritable heart. All had toxic levels of PCP in their blood and one had confirmed pre-existing disease. The Taser cannot be held solely responsible for their deaths.
- The mortality rate in these patients was no higher than that reported for PCP toxicity alone.

In another paper, Koscove describes medical implications of the Taser [15]. He makes the point that most 'tasered' individuals had been under the influence of PCP, making subjective impressions difficult. He describes a volunteer trial of the Taser on prison guards, all of whom fell to the ground but remained conscious. Most reported the experience to be unpleasant and declined to undergo the experience again. A few reported a tingling sensation in an area of 4 cm in diameter that lasted two or three minutes after being 'tasered'. Koscove discussed the potential for physical injury to the body by the barbs. He noted that penetration of the barbs into a major blood vessel had not been reported. He expressed concern about the potential for injuring the eyes, but noted that law enforcement personnel were trained to discharge the weapon at the subjects' legs and trunk and to avoid the head. He describes issues concerning barb removal. Koscove explains that the calculated electrical output of the Taser (which involved some unsubstantiated electrical engineering assumptions) was under the thresholds for causing cardiac fibrillation and asphyxia. He concludes that a 'tasered' victim with normal cardiopulmonary function would be unlikely to develop ventricular fibrillation or paralysis of the respiratory muscles. He points out that the effects of the Taser on individuals with coronary heart disease, conduction defects, pre-existing arrhythmias, pacemakers or those under the influence of alcohol or other drugs were unknown. Concerns about the effect of the Taser on cardiac pacemakers were expressed. The Taser was considered to have the potential to disrupt the software in pacemakers. Alternatively, the sudden movement caused by the Taser was thought to have the potential to disrupt the pacemaker cable and render it useless, thereby ceasing to function and putting the individual at risk from his underlying cardiac arrhythmia. Koscove points out the danger of injury in 'tasered' victims from falling after delivery of the electric shocks.

In other articles, Koscove [16,17,18,] describes his approach to 'tasered' victims. He advocates an ECG and admission of these patients for observation, to exclude cardiac complications. He also presents a case of Taser dart ingestion, which passed through the gut without complication [19].

Some untoward incidents have been reported in subjects shot with Tasers. A case report describes miscarriage in a female drug abuser who was 8-10 weeks pregnant (no drug abuse 7 days prior to Tasing), occurring one day after being 'tasered' [20]. The author concludes that the sequence of events in this case (where the current crossed the uterus), suggested a causal link between tasing and the miscarriage. The author argues that the uterus and amniotic fluid surrounding the foetus are excellent electrical conductors and would therefore deliver electricity to the foetus perhaps causing cardiac arrest. Alternatively, he postulates that the current might have caused thermal injury to the uterus and in this way led to miscarriage. This electrical theory has been challenged by Dr Stratbucker who informs that the uterus provides a Faraday shield, which would confer protection from a Taser [8].

Fish describes the effects of older stun guns: stun delivery for 0.5 seconds - startling, 1-2 seconds - unable to stand, 3-5 seconds - immobilised, dazed and weak for up to 15 minutes. The original Taser (0.8 Joules) is reported to immobilise after 2 – 3 seconds, longer application is reported to be able to cause respiratory arrest. The author points out that the treatment for victims shot with a Taser includes treatment for the condition that caused them to be shot with the Taser. Complications are cited as penetration of the eye or blood vessels by barbs or if there is secondary trauma due to falls. Fish warns that gas could be exploded by an arc current [21].

Stun guns and other electronic weaponry have reportedly been used for interrogation and torture [22]. The author describes the immediate effects as including severe pain, loss of muscle control, convulsions, fainting, and loss of sphincter control. The longer-term effects reportedly include muscle stiffness, impotence, scarring and post-traumatic stress disorder. This paper was presented by Amnesty International and was presumably based on the subjective reports of victims. No mention of mortality from electronic weaponry is made in this article. This paper was compiled from witness verbal reports and not from clinical observations.

Electrical injury

An article on the deliberate application of electric shocks addresses some of these issues [21]. Electroshock therapy has been used for psychiatric conditions for many years. Patients convulse and lose consciousness and are apnoeic (not breathing). They are expected to resume breathing within 45 seconds. They normally awake at about five minutes and then sleep for several hours. Before the introduction of anaesthesia for this procedure, there were occasional reports of fractures and dislocations from uncontrolled muscle contraction. Cardiac dysrhythmias have also been recorded in up to 43% of normal patients and in 78% of those with heart disease. Several hundred deaths have followed this treatment. Most of these deaths occurred in elderly patients, many of whom had coronary artery disease.

Several cases of myocardial infarction following electrical injury are reported. These are described following exposure to AC currents [23]. The potential to cause ventricular fibrillation is in part dependent on the length of time that the AC current is applied. The heart is vulnerable during the first part of the T wave on ECG, when heart muscle is repolarising. This accounts for 10-20% of the cardiac cycle. [24,25] Another review of the injury potential to the heart following electrical injury further describes the risk [26]. The authors state that electrical injury, especially with alternating current, has a predilection for the sino-atrial (natural pacemaker) and atrioventricular nodes. They go on to summarise the proposed mechanisms of myocardial injury following electric shock. In the acute phase, electricity can cause coronary artery spasm, direct thermal injury, arrhythmia induced hypotension and subsequent ischaemia, acute hypertension, and coronary artery ischaemia. The authors reiterate the fact that alternating current is more dangerous than direct current. They cite experimental work on dogs in which DC shocks produced fewer arrhythmias, myocardial infarction and death than AC delivery at similar energy levels. When increasing the voltage of AC shocks, it was found that the incidence of ventricular fibrillation was inversely proportional to the voltage whereas the incidence of atrial fibrillation and ventricular tachycardia was directly proportional to increases in voltage. This is said to correlate with clinical experience. AC produces tetany in muscle, which prevents let-go, and causes coronary artery spasm and subsequent myocardial ischaemia. This is said to usually involve the right coronary artery, which is closer to the chest wall than the left. Other papers also describe the risk to the heart from electric shocks. Myocardial infarcts, necrosis, arrhythmias and hypokinesia have been documented. This is considered to be due to thermal injury to

cardiac muscle and its conducting system, and arrhythmia generation leading to ischaemia [27,28,29,30,31]. The risk for cardiac injury after high voltage electrical sources is considered to be highest in individuals where the current passes vertically across the heart with enough current to cause skin burns [32].

The electrical thresholds for inducing ventricular fibrillation in man were determined experimentally by applying alternating current directly to the hearts of patients on cardiopulmonary bypass. The current was applied in three different ways using different electrode connections to the myocardium. The fibrillation thresholds were found to be 67.2, 735.5 and 199 microamperes for each mode of delivery. The authors note that *'since these measurements were performed on patients with cardiac disease, the ventricular thresholds noted may well be lower than those in healthy hearts'*. In this experiment, the current was applied directly to the heart, therefore the impedance and resistance of clothing, the body wall and the pathway were not taken into account [33]. An Indian paper also describes the effects of electricity on the heart [34]. The authors state that at currents up to 25 mA, the rhythm is unchanged. At 25 – 75 mA, the heart stops momentarily and resumes an irregular heartbeat. At 75 mA to 4 A, ventricular fibrillation is precipitated. Beyond 4 A, there is transient cardiac standstill but provided the current is discontinued, a normal heartbeat resumes.

A paper by Pliskin et al [35], describes the neuropsychiatric aspects of electrical injury. He reports that both acute and delayed neurological syndromes can follow electrical injury whether or not the head is a point of contact or not. These have included loss of consciousness, seizures, aphasia, visual disturbances, headaches, tinnitus, paresis, and memory disturbance. The damage to the central nervous system is thought to be due to several types of pathology following electrical injury. These include: thermal, electrical and mechanical damage resulting in histopathological changes such as coagulation necrosis (death of tissue due to clotting of blood vessels), reactive gliosis (increase in non-neural support cells within the central nervous system as a response to injury), demyelination (destruction of the protein covering of nerves), vacuolisation (small holes within the brain tissue), and perivascular haemorrhage (small areas of bleeding). The authors go on to describe several series of patients affected neuropsychologically by electrical injury. These series suggest that many suffer neuropsychological impairment following electrical injury. Common problems involve memory, attention, language functioning, problem solving ability and emotional disturbance in the form of anxiety and depression. They point out that most

published series included only small numbers of subjects and did not adequately take into account secondary injury from falls and head injuries occurring after the electrical shock. The type of electrical delivery and the effect of pending litigation on subjects' assessment tests were not always addressed in these series. It was also pointed out that there might have been psychological reactions contributing to subjects' symptoms. The pre-injury neuropsychiatric profile of these subjects was obviously not known, so it is difficult to quantify any change following their electrical injury. Therefore clear conclusions are difficult to draw. The authors conclude that more robust data gathering is required to determine the neuropsychological hazards of electrical injury.

A single case report describes permanent damage to the spinal cord and brain following the discharge of an anti-theft device in a victim who had previously been implanted with a spinal cord stimulator device for control of chronic pain [36].

Electrical injuries to the spinal cord and brain have been implicated in causing motor and sensory deficits, muscle imbalance, abnormal gait, impotence, quadriparesis, paraparesis, or muscle dysfunction. Injury may be permanent or temporary. The appearance of symptoms may occur over three years. Chronic pain, seizures, cataracts, cerebellar dysfunction, and post-traumatic psychoneurosis have also been described. These types of injuries are not frequent with domestic supply electricity but are described after exposure to very high voltage charges (industrial or lightning strikes). Vascular and muscular damage are associated with high voltage discharges (greater than 1000V) [37].

A small series from China describes seven deaths in welders following exposure to low voltage currents [38]. They suggest that even low voltage current can cause death if applied over the chest in sweating individuals if there is adequate duration of contact to cause skin burns. The reduced resistance of the skin caused by sweating is presumed to have contributed to these deaths.

Bones and joints can be damaged by tetanic muscle contraction or after the victim falls following electric shock [37]. Extensive muscle damage can cause chemical and metabolic abnormalities (rhabdomyolysis and myoglobinuria).

Other injuries described include eye, lung and gastrointestinal injuries including ulcers, gall stone formation and gut paralysis [31,37].

One case report describes severe abnormalities in a child delivered prematurely by Caesarean section at 30 weeks, after the mother was exposed to DC shocks earlier in the pregnancy. A causative link is not proven.

Review of company-provided material

Material from the company describes the evolution of the Advanced Taser. Attempts were made to increase the effectiveness of the system by increasing its output. The results of animal testing are described, in which the energy of Taser pulses was increased until uncontrollable contractions occurred at 1.76 Joules per pulse. (Original Taser pulses produced painful stimuli, but did not cause muscle contraction, allowing a focused victim to fight through the effects). Further animal testing at the University of Missouri failed to induce ventricular fibrillation on anaesthetised dogs. In some of these tests, drugs were used to increase the sensitivity of the heart to dysrhythmias.

Extensive human trials on healthy volunteers are described and this work continues. Two CD-ROMS provided by the company contain numerous video clips showing some of the human volunteers being shot with the Advanced Taser.

A document from Stratbucker and associates describes the results of evaluation of the Advanced Taser measuring peak current, pulse repetition rate, and damped cycle width with the non-arcing output of the pulse generator loaded into 1000 Ohms. Experimentation on an anaesthetised pig failed to produce any evidence of cardiac ectopy or myocardial injury. The author concludes that the electrical emissions from stun gun type pulse generators, delivered to the body surface in the recommended manner do not cause serious cardiac rhythm abnormalities in the otherwise healthy adult heart. A graph of body current plotted against pulse width is presented. It shows the delivery of electricity by the Advanced Taser to be under the calculated threshold to induce ventricular fibrillation. (This presumably assumes that the current is delivered directly to the heart).

Taser International has provided reports of recent operational of experience with the M26 Advanced Taser compiled from the various law enforcement agencies and organisations. No significant adverse effects have been reported to date. They have established a database of over 800 volunteers including actual field uses with zero long-term injuries and one short-term bruised shoulder from falling.

Injury rates with current UK police use of force options

Data describing injury rates from current use of force options are reproduced from the Northamptonshire Police end of year use of force report 1999 – 2000 [39]. 42 of 178 baton strikes were implicated in causing injury. Of these 33 were bruises, 4 were cuts, 1 a graze, and 4 were fractures. Thus, 23% of baton strikes resulted in injury to the subject. With regard to unarmed defensive tactics, 1.9% of primary control skills and 25% of defensive tactics caused injury to prisoners. The deployment of police dogs has an injury rate of 70% to offenders. No deaths occurred in any of the prisoners in this series. There is no available data on injury from the deployment of incapacitant sprays. The injury rates for police officers were 15% when using unarmed defensive tactics, 1% for primary control skills, 1.5% for baton use and 0% when deploying police dogs.

Personal experience with the Advanced Taser

I have experienced a 0.5 - 1 second discharge from the Advanced Taser, one barb attached to my left collar and the other to clothing over the left hip. I fell to the ground and experienced a very unpleasant painful sensation down the left side of my body and was unable to move or resist. I did not lose consciousness at any time. Immediately after cessation of the current, I was able to get to my feet. My ability to think was not impaired; I suffered no chest pain or palpitations. I was aware of a transient and mild discomfort in my jaw. Psychologically, I wanted the barbs removed immediately, and most certainly did not want to receive another delivery from the device. I was able to communicate and comply with commands.

Discussion

There is no published clinical experience with the Advanced Taser. This will undoubtedly change in the future. Until then, we have to learn from experience with older stun devices, original Tasers, animal and volunteer testing, and draw some conclusions from the injury potential of other forms of electricity.

Much has been written on injuries caused by electricity. The nature and scale of injury is influenced by the physical properties of the delivered electricity. Such variables include voltage, current, frequency, duration of application, method of application, resistance of the skin, and pre-existing medical conditions. Much is known about the hazards of domestic and industrial supply electricity delivering 120 – 250 V, 50 – 60 Hz sinusoidal currents. There is however, little accurate information on the mode and magnitude of electricity delivered to the internal organs by electronic weaponry. There are several factors to consider. The Taser doesn't deliver 60 Hz sinusoidal current but rather a pulse train of damped sinusoidal waves. To date, there is little published knowledge of the clinical effects of a train of these damped sinusoidal waves. It is postulated that because the Advanced Taser delivers very high frequency, high voltage, pulsed electricity; it will behave very differently from the other more common modes of electrical delivery. The injury potential is theoretically less for electricity delivered by the Advanced Air Taser due to the *skin effect* in this manner. This will need to be proven in the course of time after more operational and clinical experience accrues.

Animal testing is of limited benefit when assessing the safety profile of restraint devices and weaponry for deployment on humans. The electrical properties of the M26 Advanced Taser and earlier stun devices have been estimated in the laboratory and some experimental work has been performed on animals and human volunteers.

In most of these tests some very broad assumptions about the resistance of human skin have been made. Skin resistance is the most important factor controlling the passage of electricity into the human body, and hence the injury potential. The Taser is designed to be largely independent of resistance in the circuit as it delivers a fixed current, and therefore the resistance of the human skin may not be important in determining how much electrical energy is delivered by electronic weaponry.

My impression is that it will be very difficult to determine absolute safety for any given quantity or nature of electrical energy delivered by these weapons. On one hand, direct discharges into animal heart muscle did not cause ventricular fibrillation, but in earlier (disputed) work, short episodes of cardiac standstill were caused and doubts raised about the effectiveness of pacemakers under Taser stimulation.

The Advanced Air Taser reportedly delivers about four times the energy than earlier stun devices and may possibly therefore cause more injury. However, such damage has not been reported in human volunteers. The fact that more electrical energy is delivered by this newer device is supported by the fact that the M26 is operationally more effective, and to date, anecdotally, no subject (neither volunteer nor violent suspect) has been able to fight through it.

Elderly subjects and those with pre-existing heart disease are perhaps at an increased risk of cardiac complications and death following exposure to large quantities of electrical energy. Since the elderly and heart patients don't often require to be subdued or controlled with a high level of force, then this is unlikely to pose a common problem.

There is not enough proof either way to determine the risk to those with implantable defibrillators or pacemakers.

I do not believe that any of the deaths described in subjects who had been 'tasered' during their arrest can be conclusively linked to the use of these devices. It seems to me that these individuals shared acknowledged and well-established risk factors of more 'routine' deaths in custody. Namely, young males, with an association with drug abuse who had exhibited bizarre behaviour or who had shown signs of excited delirium just prior to arrest.

There is also no convincing evidence that 'tasered' subjects have a higher than average risk of developing major cardiac or other serious complications. Allen expressed concern that drug ingestion could make subjects more prone to cardiac arrhythmias. This was not reproduced in animal testing.

All deaths have occurred whilst in custody after Taser electrical delivery rather than during or immediately afterwards. The authors of this report have personally found that there is a small

time-period after experiencing a short discharge from the Advanced Taser during which there is both a physiological and psychological reaction. This reaction might possibly exacerbate the effects of illicit drugs. However a similar exacerbation may well be caused by other methods of restraint or physical conflict.

There have been concerns that pregnant women might be at increased risk of miscarriage and fetal abnormalities, although I do not consider that this has been proven. It has been argued that the uterus and amniotic fluid surrounding the foetus are excellent electrical conductors and would therefore deliver electricity to the foetus perhaps causing cardiac arrest. It was also postulated that alternatively, the current might cause thermal injury to the uterus and in this way lead to miscarriage. Dr Stratbucker has advised that if the uterus and the amniotic fluid are good conductors, then they represent a Faraday shield, and therefore according to Gauss' Law there cannot be an electric field within them. He also advises that the Taser-delivered currents are so low, that they do not in and of themselves cause any electric effects, much less thermal effects.

Stun guns and Taser barbs cause minor skin burns. These are most unlikely to be of long-term significance in non-sensitive skin areas. Even though there have been no reports of significant injury to date from the Taser barbs, this does have the potential to be a problem in future deployment. Injuries might be expected for barb strikes to the eyes, neck, genitals, open mouth and femoral vessels in the groin. The risk of this occurrence can be reduced by training and using the laser sight, although accurate aiming of the weapon in a conflict situation might prove difficult. This is an operational issue that needs to be addressed by qualified trainers.

Violent muscle spasms caused by the tasering might conceivably cause fractures and dislocations. Injuries may also occur if the victim falls after being shocked.

The Taser has a lower injury potential for prisoners than current use of unarmed defensive tactics, baton strikes and deployment of police dogs. The Taser almost certainly poses a lower threat to police operatives using these alternative use of force options.

Notwithstanding the potential medical risks described, stun devices are certainly less lethal than firearms and if they are to be deployed in similar circumstances and level of threat, then the outcome will almost certainly be safer.

Deaths in custody continue to occur at the rate of approximately one a week in the UK. Questions will undoubtedly arise when the first 'tasered' victim dies in custody. This I fear is inevitable, as both 'tasered' subjects and those dying in custody share some common risk factors. To date, the American experience with 'tasered' deaths in custody has not been able to conclusively link post mortem findings to use of the Taser. All victims had other identifiable factors that could have killed them. These, as stated, were common to non-'tasered' deaths in custody.

Some 'tasered' victims might later pursue litigation claiming that the Taser caused or precipitated epilepsy, neurological damage, miscarriage or other medical problem. They might cite some of the case reports presented in this paper. Psychological damage also has the potential to become a very difficult area of litigation. This will need to be carefully handled and may be difficult to defend.

There are perhaps some operational risks in deploying Tasers. This might include ignition of flammable chemicals and gases. Some operational consideration will need to be given to different scenario work in training. The use of the weapon on a subject in a crowd or standing near the edge of a building or other hazardous environment will need to be evaluated. This will need to be addressed through training.

The use of electric weapons has been linked to torture and interrogation in some regimes and in some crimes including child abuse. Depending on how their introduction might be publicised in the media, their use might be construed as a potential weapon of torture. This I believe has the potential to be used against the police to support claims of torture or even racial abuse. Some protection from this scenario is clearly provided by the data port in the device, which should prove lawful deployment.

Summary

The medical risks of electronic weaponry compare favourably with those of more conventional methods of controlling non-compliant and violent subjects. It has been impossible to accurately calculate how much electrical energy the Advanced Taser delivers into the human body.

There exists no convincing evidence directly implicating Taser weaponry in deaths of subjects in over 25 years' experience in America.

Risk factors for death in 'tasered' subjects appear to be no different from known risk factors for death in custody (drugs, exhaustion, bizarre behaviour leading to arrest etc).

The risk of harm might well be higher for using these devices on patients with pre-existing heart and neurological diseases. These risks are largely theoretical and have not been demonstrated in field application or laboratory testing to date.

The risks to patients with implanted pacemakers and defibrillators are probably quite small.

The potential for significant injury exists for Taser barbs striking the eye, open mouth, neck, genitals, and large blood vessels in the groin.

The Taser delivers electricity that incapacitates the subject and ends the physical, (and likely the psychological), resistance to arrest. It causes a degree of stunning. Much useful data has been gained from over 800 volunteers. More work is required to record the effects of the Taser on physiological variables and ECG tracings.

The Taser is most unlikely to cause any permanent physical problems in healthy individuals.

Litigation can be expected for 'tasered' deaths in custody, or those who go on to develop other medical or psychological conditions. Based on the available medical literature to date, there is no solid basis for potential claimants to pursue successful litigation with the exception perhaps of post traumatic stress disorder.

The media portrayal of the introduction of these weapons needs to be handled very carefully.

References

1. Webster JG Minimising cutaneous pain during electrical stimulation. Ninth Conference of the Engineering in Medicine and Biology Society 1987
2. Panescu D, Cohen KP, Webster JG, Stratbucker RA The Mosaic Characteristics of the Skin *IEEE Transactions on Biomedical Engineering* Vol 40 No 5 1993
3. Panescu D, Webster JG, Stratbucker RA A Nonlinear Electrical-Thermal Model of the Skin *IEEE Transactions on Biomedical Engineering* Vol 41 No 7 p672 1994
4. Panescu D, Webster JG, Stratbucker RA A Nonlinear Finite Element Model of the Electro-Electrolyte-Skin System *IEEE Transactions on Biomedical Engineering* Vol 41 No 7 p681 1994
5. Letter from Professor Harrison from the Department of Electronics, Carleton University, Canada (supplied by Taser International).
6. Frechette A, Rimsa ME, Stun Gun Injury: A New Presentation of the Battered Child Syndrome *Pediatrics* Vol 89 No 5 p898 1992
7. O'Brien DJ. Electronic weaponry--a question of safety [published erratum appears in *Ann Emerg Med* 1991 Sep;20(9):1031]. *Annals of Emergency Medicine* 1991;20:583-7.
8. Personal communication from Dr Stratbucker via Taser International
9. Odell M. The human body as an electric circuit. *Journal of Clinical Forensic Medicine* 1997;4:1-6
10. Jain S, Bandi V. Electrical and lightning injuries. [Review] [106 refs]. *Critical Care Clinics* 1999;15:319-31.
11. Walpole BG. Electric shock. *Australian Family Physician* 1989;18:1252-6.
12. Cooper MA. Emergent care of lightning and electrical injuries. *Seminars in Neurology* 1995;15:268-78.
13. Kornblum RN, Reddy SK. Effects of the Taser in fatalities involving police confrontation *Journal of Forensic Sciences* 1991;36:434-8.
14. Allen TB. Discussion of "Effects of the taser in fatalities involving police confrontation" *Journal of Forensic Sciences* 1992;37:956-8.
15. Ordog GJ, Wasserberger J, Schlater T, Balasubramaniam S. Electronic gun (Taser) injuries. *Annals of Emergency Medicine* 1987;16:73-8.
16. Koscove EM. The Taser weapon: a new emergency medicine problem. *Annals of Emergency Medicine* 1985;14:1205-8.
17. Koscove E. The Taser: research, patients, and language (Tom Swift found). *Journal of Emergency Medicine* 1988;6:343-4.

18. Koscove E. Taser power. *Annals of Emergency Medicine* 1987;**16**:1190
19. Koscove EM. Taser dart ingestion. *Journal of Emergency Medicine* 1987;**5**:493-8.
20. Mehl LE. Electrical injury from Taser and miscarriage. *Acta Obstetrica et Gynecologica Scandinavica* 1992;**71**:118-23
21. Fish R. Electric shock, Part III: Deliberately Applied Electric Shocks and the Treatment of Electric Injuries *Journal of Emergency Medicine* 1993;**11**:599-603
22. Welsh J. Electroshock torture and the spread of stun technology. *Lancet* 1997;**349**:1247
23. Wijesundere A, Nagaratnam N. Myocardial injury following electric shock *Ceylon Medical Journal* 1979;**24**:45-6
24. Odell M. The human body as an electric circuit. *Journal of Clinical Forensic Medicine* 1997;**4**:1-6
25. Forrest FC, Saunders PR, McSwinney M, Tooley MA. Cardiac injury and electrocution. *Journal of the Royal Society of Medicine* 1992;**85**:642-3
26. Robinson NM, Chamberlain DA. Electrical injury to the heart may cause long-term damage to conducting tissue: a hypothesis and review of the literature. *International Journal of Cardiology* 1996;**53**:273-7
27. Romero B, Candell-Riera J, Gracia RM, Fernandez MA, Aguade S, Peracaula *et al*. Myocardial necrosis by electrocution: evaluation of noninvasive methods. *Journal of Nuclear Medicine* 1997;**38**:250-1
28. Fontanarosa PB. Electrical shock and lightning strike. *Annals of Emergency Medicine* 1993;**22**:378-87
29. James TN, Riddick L, Embry JH. Cardiac abnormalities demonstrated postmortem in four cases of accidental electrocution and their potential significance relative to nonfatal electrical injuries of the heart. *American Heart Journal* 1990;**120**:143-57
30. Homma S, Gillam LD, Weyman AE. Echocardiographic observations in survivors of acute electrical injury. *Chest* 1990;**97**:103-5
31. Wilkinson C, Wood M. High voltage electric injury. *American Journal of Surgery* 1978;**136**:693-6
32. Chandra NC, Siu CO, Munster AM. Clinical predictors of myocardial damage after high voltage electrical injury. *Critical Care Medicine* 1990;**18**:293-7
33. Watson AB, Wright JS, Loughman J. Electrical thresholds for ventricular fibrillation in man. *Medical Journal of Australia* 1973;**1**:1179-82
34. Arya KR, Taori GK, Khanna SS. Electrocardiographic manifestations following electric injury. *International Journal of Cardiology* 1996;**57**:100-1

35. Pliskin NH, Meyer GJ, Dolske MC, Heilbronner RL, Kelley KM, Lee RC. Neuropsychiatric aspects of electrical injury: A review of neuropsychological research. *Annals of the New York Academy of Sciences* 1994;**720**
36. Eisenberg E, Waisbrod H. Spinal cord stimulator activation by an antitheft device. Case report. *Journal of Neurosurgery* 1997;**87**:961-2
37. Fish R. Electric shock, Part II: Nature and mechanisms of injury. *Journal of Emergency Medicine* 1993;**11**:457-62
38. Zhang P, Cai S. Study on electrocution death by low-voltage. *Forensic Science International* 1995;**76**:115-9
39. Northamptonshire Police end of year use of force report 1999 – 2000

Appendix A. Results of Medline Literature Search

1. Allen TB. Discussion of "Effects of the taser in fatalities involving police confrontation" [letter; comment]. *Journal of Forensic Sciences* 1992;**37**:956-8.
2. Mehl LE. Electrical injury from Taser and miscarriage. [Review] [45 refs]. *Acta Obstetrica et Gynecologica Scandinavica* 1992;**71**:118-23.
3. Kornblum RN, Reddy SK. Effects of the Taser in fatalities involving police confrontation [see comments]. *Journal of Forensic Sciences* 1991;**36**:434-8.
4. O'Brien DJ. Electronic weaponry--a question of safety [published erratum appears in *Ann Emerg Med* 1991 Sep;**20**(9):1031]. [Review] [33 refs]. *Annals of Emergency Medicine* 1991;**20**:583-7.
5. Koscove E. The Taser: research, patients, and language (Tom Swift found) [letter]. *Journal of Emergency Medicine* 1988;**6**:343-4.
6. Koscove EM. Taser dart ingestion. *Journal of Emergency Medicine* 1987;**5**:493-8.
7. Koscove E. Taser power [letter]. *Annals of Emergency Medicine* 1987;**16**:1190.
8. Ordog GJ, Wasserberger J, Schlatter T, Balasubramaniam S. Electronic gun (Taser) injuries. *Annals of Emergency Medicine* 1987;**16**:73-8.
9. Koscove EM. The Taser weapon: a new emergency medicine problem. *Annals of Emergency Medicine* 1985;**14**:1205-8.
10. VanDenburg S, McCormick GM, Young DB. Investigation of deaths related to electrical injury. *Southern Medical Journal* 1996;**89**:869-72.
11. Zhang P, Cai S. Study on electrocution death by low-voltage. [Review] [4 refs]. *Forensic Science International* 1995;**76**:115-9.
12. Puschel K, Lockemann U, Bartel J. Postmortem investigation of serum myoglobin levels with special reference to electrical fatalities. *Forensic Science International* 1995;**72**:171-7.

13. Goodson ME. Electrically induced deaths involving water immersion. *American Journal of Forensic Medicine & Pathology* 1993;**14**:330-3.
14. Mellen PF, Weedn VW, Kao G. Electrocution: a review of 155 cases with emphasis on human factors. *Journal of Forensic Sciences* 1992;**37**:1016-22.
15. Allen TB. Discussion of "Effects of the taser in fatalities involving police confrontation" [letter; comment]. *Journal of Forensic Sciences* 1992;**37**:956-8.
16. Dressler J, Muller E. [Death caused by electric injury from the forensic medicine viewpoint]. [German]. *Zeitschrift für Arztliche Fortbildung (Jena)* 1990;**84**:1159-61.
17. al Alousi LM. Homicide by electrocution. *Medicine, Science & the Law* 1990;**30**:239-46.
18. Welsh J. Electroschock torture and the spread of stun technology. *Lancet* 1997;**349**:1247.
19. Bork K, Nagel C. Long-standing pigmented keloid of the ears induced by electrical torture. *Journal of the American Academy of Dermatology* 1997;**36**:490-1.
20. Patel F. Homicidal manual strangulation and multiple stun gun injuries [letter; comment]. *American Journal of Forensic Medicine & Pathology* 1993;**14**:271.
21. Ikeda N, Harada A, Suzuki T. Homicidal manual strangulation and multiple stun-gun injuries [see comments]. *American Journal of Forensic Medicine & Pathology* 1992;**13**:320-3.
22. Dressler J, Muller E. [Death caused by electric injury from the forensic medicine viewpoint]. [German]. *Zeitschrift für Arztliche Fortbildung (Jena)* 1990;**84**:1159-61.
23. Karlsmark T. Electrically induced dermal changes. A morphological study of porcine skin after transfer of low-moderate amounts of electrical energy. [Review] [110 refs]. *Danish Medical Bulletin* 1990;**37**:507-20.
24. Koscove EM. The Taser weapon: a new emergency medicine problem. *Annals of Emergency Medicine* 1985;**14**:1205-8.
25. Karlsmark T, Thomsen HK, Danielsen L, Aalund O, Nielsen O, Nielsen KG *et al*. Tracing the use of electrical torture. *American Journal of Forensic Medicine &*

26. Kosa F., Viragos KE. [Sudden death after "home electrotherapy"]. [Hungarian]. *Morphologiai Es Igazsagugyi Orvosi Szemle* 1978;18:311-2.
Ref ID: 26
27. Dyhre-Poulsen P, Rasmussen L, Rasmussen OV. [Study of an instrument for electric torture]. [Danish]. *Ugeskrift for Laeger* 1977;139:1054-6.
28. Knight B. Forensic problems in practice. XI.--Injury from physical agents. *Practitioner* 1976;217:813-8.
29. Carlsson L, Maehly AC, Rudh E. [Attempted murder with electric current. Criminal-technical investigation]. [German]. *Archiv fur Kriminologie* 1976;157:30-6.
30. Schneider V. [Remarkable cases of electric current induction for criminal purposes]. [German]. *Archiv fur Kriminologie* 1973;151:149-58.
31. Buss A, Booker A, Buss E. Firing a weapon and aggression. *Journal of Personality & Social Psychology* 1972;22:296-302.
32. Panksepp J. Drugs and stimulus-bound attack. *Physiology & Behavior* 1971;6:317-20.
33. Bowen DA. Medical investigation in cases of sudden death. *British Medical Journal* 1967;2:33-6.
34. Jain S., Bandi V. Electrical and lightning injuries. [Review] [106 refs]. *Critical Care Clinics* 1999;15:319-31.
35. Romero B, Candell-Riera J, Gracia RM, Fernandez MA, Aguade S, Peracaula *et al.* Myocardial necrosis by electrocution: evaluation of noninvasive methods. *Journal of Nuclear Medicine* 1997;38:250-1.
36. Arya KR, Taori GK, Khanna SS. Electrocardiographic manifestations following electric injury. *International Journal of Cardiology* 1996;57:100-1.
37. Robinson NM, Chamberlain DA. Electrical injury to the heart may cause long-term damage to conducting tissue: a hypothesis and review of the literature. [Review] [20 refs]. *International Journal of Cardiology* 1996;53:273-7.

38. Fish R. Electric shock, Part II: Nature and mechanisms of injury. [Review] [41 refs]. *Journal of Emergency Medicine* 1993;**11**:457-62.
39. Fontanarosa PB. Electrical shock and lightning strike. [Review] [101 refs]. *Annals of Emergency Medicine* 1993;**22**:378-87.
40. Forrest FC, Saunders PR, McSwinney M, Tooley MA. Cardiac injury and electrocution. *Journal of the Royal Society of Medicine* 1992;**85**:642-3.
41. Fechner G, Brinkmann B, Heckmann M. [Heart current density as the most important biological parameter of electrocution in the bathtub]. [German]. *Beitrage zur Gerichtlichen Medizin* 1990;**48**:335-8.
42. James TN, Riddick L, Embry JH. Cardiac abnormalities demonstrated postmortem in four cases of accidental electrocution and their potential significance relative to nonfatal electrical injuries of the heart. *American Heart Journal* 1990;**120**:143-57.
43. Avitall B, Port S, Gal R, McKinnie J, Tchou P, Jazayeri M *et al.* Automatic implantable cardioverter/defibrillator discharges and acute myocardial injury. *Circulation* 1990;**81**:1482-7.
44. Chandra NC, Siu CO, Munster AM. Clinical predictors of myocardial damage after high voltage electrical injury. *Critical Care Medicine* 1990;**18**:293-7.
45. Homma S, Gillam LD, Weyman AE. Echocardiographic observations in survivors of acute electrical injury. *Chest* 1990;**97**:103-5.
46. Walpole BG. Electric shock. *Australian Family Physician* 1989;**18**:1252-6.
47. Fillette F, Lascault G, Nassif G, Fontaliran F, Aouate P, Grosogeat Y. [Cellular effects of electric shock. Definitions, physical principles, cellular electrophysiology and morphological analysis of the shocked areas]. [French]. *Archives des Maladies du Coeur et des Vaisseaux* 1987;**80**:1553-63.
48. McBride JW, Labrosse KR, McCoy HG, Ahrenholz DH, Solem LD, Goldenberg *et al.* Is serum creatine kinase-MB in electrically injured patients predictive of myocardial injury? *JAMA* 1986;**255**:764-8.
49. Hofmann P. [Experiences with electrical accidents]. [German]. *Zeitschrift Fur Unfallmedizin Und Berufskrankheiten* 1980;**73**:4-37.

50. Wijesundere A.,Nagaratnam N. Myocardial injury following electric shock *Ceylon Medical Journal* 1979;**24**:45-6.
Ref ID: 50
51. Wilkinson C.,Wood M. High voltage electric injury. *American Journal of Surgery* 1978;**136**:693-6.
52. Hackl JM, Puschendorf B, Dienstl F, Dworzak E, Haid B. [The value of CKMB in multiple trauma and high voltage injuries]. [German]. *Infusionstherapie und Klinische Ernährung* 1978;**5**:204-7.
53. Watson AB, Wright JS, Loughman J. Electrical thresholds for ventricular fibrillation in man. *Medical Journal of Australia* 1973;**1**:1179-82.
54. Starmer CF, McIntosh HD, Whalen RE. Electrical hazards and cardiovascular function. *New England Journal of Medicine* 1971;**284**:181-6.
55. Gavaller L.,Novak J. [Data on the pathogenesis and therapy of electric shock and electric burns]. [German]. *Zeitschrift fur Arztliche Fortbildung (Jena)* 1968;**62**:693-700.
56. Ernst S. [Electrocardiographic examination following electric trauma. On the differential diagnosis of negative T-waves]. [German]. *Monatsschrift fur Unfallheilkunde, Versicherungs-, Versorgungs- und Verkehrsmedizin* 1966;**69**:210-7.
57. Voegtlin R, Hessel F, Diesel J. [Lesions of the myocardium caused by electrocution. The coronary type of electrocardiographic images]. [French]. *Strasbourg Medical* 1965;**16**:563-70.
58. Ordog GJ, Wasserberger J, Schlater T, Balasubramaniam S. Electronic gun (Taser) injuries. *Annals of Emergency Medicine* 1987;**16**:73-8.
59. Trapp AL.,Taylor RF. Methods of euthanasia in poultry and food-producing animals. *Veterinary Clinics of North America - Food Animal Practice* 1986;**2**:31-41.
60. Yamanouchi Y, Mowrey KA, Kroll MW, Brewer JE, Donohoo AM, Wilkoff BL *et al.* Optimized first phase tilt in 'parallel-series' biphasic waveform. *Journal of Cardiovascular Electrophysiology* 1997;**8**:649-57.
61. Cooper MA. Emergent care of lightning and electrical injuries. *Seminars in Neurology* 1995;**15**:268-78.

62. Forrest FC, Saunders PR, McSwinney M, Tooley MA. Cardiac injury and electrocution. *Journal of the Royal Society of Medicine* 1992;**85**:642-3.
63. Chibber CN, Siu CO, Munster AM. Clinical predictors of myocardial damage after high voltage electrical injury. *Critical Care Medicine* 1990;**18**:293-7.
64. Eisenberg E, Waishrod H. Spinal cord stimulator activation by an antitheft device. Case report. *Journal of Neurosurgery* 1997;**87**:961-2.
65. Odell M. The human body as an electric circuit. *Journal of Clinical Forensic Medicine* 1997;**4**:1-6.
66. Pliskin NH, Meyer GJ, Dolske MC, Heilbronner RL, Kelley KM, Lee RC. Neuropsychiatric aspects of electrical injury: A review of neuropsychological research. *Annals of the New York Academy of Sciences* 1994;**720**.
67. Tatham TA, Gyorda AM, Barrett JE. Shock postponement reverses the effects of cocaine on the punished pecking of pigeons. *Pharmacology, Biochemistry & Behavior* 1994;**48**:491-5.
68. Goodson ME. Electrically induced deaths involving water immersion. *American Journal of Forensic Medicine & Pathology* 1993;**14**:330-3.
69. Petkov VD, Kehayov RA, Mosharrof AH, Petkov VV, Getova D, Lazarova MB *et al*. Effects of cytidine diphosphate choline on rats with memory deficits. *Arzneimittel-Forschung* 1993;**43**:822-8.
70. Tatham TA, Barrett JE. Shock avoidance but not DRL history reverses the effects of cocaine on punished behavior of squirrel monkeys. *Behavioural Pharmacology* 1993;**4**:159-66.
71. Ikeda N, Harada A, Suzuki T. Homicidal manual strangulation and multiple stun-gun injuries. *American Journal of Forensic Medicine & Pathology* 1992;**13**:320-3.
72. Mehl LE. Electrical injury from tasering and miscarriage. *Acta Obstetrica et Gynecologica Scandinavica* 1992;**71**:118-23.
73. Wiley JL, Porter JH, Compton AD, Balster RL. Antipunishment effects of acute and repeated administration of phencyclidine and NPC 12626 in rats. *Life Sciences*

1992;**50**:1519-28.

74. Kornblum RN, Reddy SK. Effects of the Taser in fatalities involving police confrontation. *Journal of Forensic Sciences* 1991;**36**:434-48.
75. Korte SM, Moolhaas JM, Schuurman T, Traber J, Bohus B. Anxiolytics and stress-induced behavioural and cardiac responses: A study of diazepam and ipsapirone (TVX Q 7821). *European Journal of Pharmacology* 1990;**179**:393-401.